PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

REC'D 08 MAR 2006
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Applicant's or agent's file reference	FOR FURTHER ACTION See Form PCT/IPEA/416	
P06652PCOO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SE2004/000359	11-03-2004	
International Patent Classification (IPC) or national classification and IPC		
See Supplemental Box		
Applicant		
Telefonaktiebolaget L M Ericsson (publ)et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *(sent to the applicant and to the International Bureau)* a total of 5 sheets, as follows:
      ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) _____, containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the report
   - ☐ Box No. II Priority
   - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☐ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☐ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
05-01-2006	01-03-2006
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. +46 8 667 72 88	Authorized officer Åsa Rydenius /itw Telephone No. +46 8 782 25 00

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of: Cover sheet

INTERNATIONAL PATENT CLASSIFICATION (IPC):

H01Q 1/00 (2006.01)
H01Q 21/30 (2006.01)
H04B 7/08 (2006.01)

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2004/000359

Box No. I Basis of the report

1. With regard to the **language**, this report is based on:

☐ the international application in the language in which it was filed

☐ a translation of the international application into _____ ,
which is the language of a translation furnished for the purposes of:

☐ international search (Rules 12.3(a) and 23.1(b))

☐ publication of the international application (Rule 12.4(a))

☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

☐ the international application as originally filed/furnished

☒ the description:

pages 1-2, 4-8 as originally filed/furnished

pages* 3 received by this Authority on 02-02-2006

pages* _____ received by this Authority on _____

☒ the claims:

pages _____ as originally filed/furnished

pages* _____ as amended (together with any statement) under Article 19

pages* 9-12 received by this Authority on 05-01-2006

pages* _____ received by this Authority on _____

☒ the drawings:

pages 1-7 as originally filed/furnished

pages* _____ received by this Authority on _____

pages* _____ received by this Authority on _____

☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheets/figs _____

☐ the sequence listing *(specify)*: _____

☐ any table(s) related to the sequence listing *(specify)*: _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheets/figs _____

☐ the sequence listing *(specify)*: _____

☐ any table(s) related to the sequence listing *(specify)*: _____

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2004/000359

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-16	YES
	Claims		NO
Inventive step (IS)	Claims	1-16	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-16	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

Documents cited in the International Search Report:
D1: WO9926317
D2: US5280472
D3: US6047199

The cited documents represent the general state of the art. The invention defined in claims 1-16 is not disclosed by any of these documents.
The cited prior art does not give any indication that would lead a person skilled in the art to the claimed method, receiver diversity antenna arrangement, frequency converter, base station and site for reducing the number of feeders in an antenna diversity system. Therefore, the claimed invention is not obvious to a person skilled in the art.
Accordingly, the invention defined in claims 1-16 is novel and is considered to involve an inventive step. The invention is industrially applicable.

this is indicated at brace 33. In each one of the four branches a respective user band is present and it is the same (in terms of kHz) in all branches. A feeder, however, is capable to transport signals on all the frequencies up to several GHz including the full RX band 32. It is thus apparent that the feeder in each branch is utilized with poor efficiency.

In principle one TRX is sufficient to diversity process the four RX signals and obtain the enhanced RX signal. A radio base station is however designed to handle large traffic volumes and therefore, and also for safety reasons, it comprises many TRXes. The output of each LNA is for this reason connected to all transceivers of the radio base station, as is shown by the various arrows, collectively shown at 34.

US 6,505 041 discloses a base station with an antenna diversity system connected to a multi coupler from which the antenna signals are fed to the respective receivers in individual feeders.

A drawback with the prior art is that each branch requires its own feeder. A diversity antenna system with many antennas will thus require as many feeders as there are antennas. Feeders are expensive. They are also heavy. Antennas are less expensive. Therefore, systems comprising many diversity antennas are prohibitive from economical point of view although they would be beneficial from reception quality point of view.

SUMMARY OF THE INVENTION

One object of the invention is to reduce the number of feeders compared with prior art and provide a method device, radio base station and system in accordance with claims 1, 7, 11 and 12.

A characteristic feature of the invention is to move/frequency translate an RX signal received on one diversity antenna to a non used frequency and to consolidate/combine the frequency translated signal with an RX signal, that has not been frequency translated, and to forward the resulting composite signal on a single feeder to the radio base station.

Depending on the radio system in which the invention is used the meaning of "frequency" and "signal frequency" may be different. A preferred implementation of the invention is cellular mobile radio systems such as WCDMA, GSM, AMPS, NMT. The bandwidth of an WCDMA signal is 5 MHz, in GSM 200 kHz, in AMPS 30 kHz

CLAIMS OF JANUARY 2006

1. A method for reducing the number of feeders between a radio base station (1) and a receiver (RX) diversity antenna arrangement that comprises at least two spaced apart antennas (10-13) each adapted for reception of individual RF signals, said RF signals all being at the same frequency **characterized by** converting one or more received antenna signals into a corresponding number of IF (intermediate frequency) signals by mixing with a first set of a corresponding number of reference signals (f1-f4), and forwarding the signals received on all the antennas, of which one or more have been frequency converted to the base station on a single feeder (2, 4).

2. A method in accordance with claim 1 wherein the diversity antenna arrangement comprises n (n=integer) antennas **characterized by** converting all received antenna signals except one, and forwarding the non-converted antenna signal together with all converted IF signals to the radio base station on the single feeder, thus providing n-way diversity with one (a single) feeder.

3. A method in accordance with claim 1 wherein the diversity antenna arrangement comprises n (n=integer) antennas **characterized by** converting all received antenna signals and forwarding them to the radio base station on the single feeder thus providing n-way diversity with one (a single) feeder.

4. A method in accordance with claim 1, **characterized by** converting the IF signals to second IF frequencies by mixing them with a second set of reference signals (f5-f7) in order to obtain a second set of IF signals which are forwarded to the base station on the single feeder..

5. A method in accordance with claim 1 wherein the diversity antenna arrangement comprises a first (10) and a second (11) antenna **characterized by** converting the antenna signal on the second antenna into an IF signal and forwarding the IF signal together with the non-converted antenna signal on the first antenna to the radio base station on a single feeder (2) , thus providing 2-way diversity with one (a single) feeder.

6. A method in accordance with claim 1 wherein there are two diversity antenna arrangements, one comprising a first (10) and a second (11) antenna, the other comprising a third (12) and fourth (13) antenna **characterized by** converting the

RF signals from the second and fourth antennas into a first and second IF signals, both of the same intermediate frequency, forwarding the non-converted antenna signal on the first antenna together with the first IF signal on a first feeder (2) to the base station, and forwarding the non-converted antenna signal on the third antenna together with the second IF signal on a second feeder (4) to the base station, thus providing 4 way diversity with two feeders (2, 4).

7. A method in accordance with any of claims 1 to 5 **characterized by** converting, at the radio base station, the IF signals into other IF signals, all on the same intermediate frequency, by mixing them with a set of reference signals (f5-f8) and subjecting the twice frequency converted signals on the common intermediate frequency to diversity signal processing.

8. A receiver (RX) diversity antenna arrangement comprising at least two diversity antennas (10-13) each adapted for reception of individual RF signals, said RF signals all being of the same frequency **characterized by** one or more frequency converters (36-38) each adapted to convert a respective antenna signal to a respective intermediate frequency signal (IF signal) by mixing it with a predetermined frequency (f1, f2, f3 or f4), a combiner (39) combining the signals received on all the antennas, of which signals one or more have been frequency converted, to form a composite signal which is forwarded to the radio base station on a single feeder (2, 4).

9. A receiver (RX) diversity antenna arrangement in accordance with claim 8, wherein an RX signal from a diversity antenna follows a diversity branch (A-D) **characterized by** providing a frequency converter (36-38) in each diversity branch except one.

10. A receiver (RX) diversity antenna arrangement in accordance with claim 8 , wherein an RX signal from a diversity antenna follows a diversity branch (A-D) **characterized by** providing a frequency converter (46, 36-38) in each diversity branch.

11. A receiver (RX) diversity antenna arrangement in accordance with claim 7, **characterized by** a second set of frequency converters (47-49) adapted to convert the first set of IF signals into a second set of IF signals for transport to the radio base station on the single feeder.

12. A receiver (RX) diversity antenna arrangement in accordance with claim 7 or 8 wherein there are two diversity antennas (10, 11), one (10) of which is connected to a first duplex filter (14) so as to provide for reception and transmitting **characterized by** a single frequency converter (36) converting the antenna signal from the second antenna (11) to an intermediate frequency to form an IF signal, the combiner (39) combining the original RX signal from the first antenna (10) with the IF signal into a composite signal, and a single feeder (2) forwarding the composite signal to the base station, thus providing 2-way diversity with one (a single) feeder (2).

13. A receiver (RX) diversity antenna arrangement in accordance with claim 9 **characterized by** duplicating the diversity antenna arrangement in order to provide a composite diversity antenna arrangement comprising four antennas (10-13) and two feeders (2,4), each antenna arrangement comprising a respective single feeder. thus providing 4-way diversity with two feeders.

14. A frequency converter unit for use with at least one feeder (2) on which a plurality of signals at mutually different frequencies are transported on a single feeder, **characterized by** a corresponding plurality of frequency converters (55-58) for converting the signals into a corresponding number of signals all at the same frequency (RX1).

15. A radio base station comprising a transceiver (TRX) with a plurality of frequency converters adapted to provide frequency translated signals, called diversity signals, all at the same frequency and means for signal processing the diversity signals in order to obtain an enhanced signal **characterized by** means connected to the input of the transceiver and adapted to receive from one single feeder at least one intermediate frequency signal (IF signal) together with either a non-frequency translated RX antenna signal and/or other frequency converted IF signals, and to supply said latter signals to respective ones of said frequency converters so as to provide said diversity signals.

16. A site comprising a radio base station (RBS), at least one tower-mounted unit (TMA) with filters (14) and RF amplifiers (17), at least two antennas (10-13) for providing diversity, the signals received by the antennas being RF signals which all are of the same frequency **characterized by** at least one frequency converter (36-38) provided in the TMA and connected to one of the diversity

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antennas in order to convert the antenna's RF signal into an IF signal at a non-used frequency, and a combiner (39) combining the IF signal with either a non-converted RF antenna signal and/or other converted IF signals into a composite signal which is applied to a single feeder (2, 4) extending between the TMA and the RBS.